

Is insufficient quantity and quality of sleep a risk factor for neck, shoulder and low back pain? A longitudinal study among adolescents

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Abstract The quantity and quality of adolescents' sleep may have changed due to new technologies. At the same time, the prevalence of neck, shoulder and low back pain has increased. However, only a few studies have investigated insufficient quantity and quality of sleep as possible risk factors for musculoskeletal pain among adolescents. The aim of the study was to assess whether insufficient quantity and quality of sleep are risk factors for neck (NP), shoulder (SP) and low back pain (LBP). A 2-year follow-up survey among adolescents aged 15–19 years was (2001–2003) carried out in a subcohort of the Northern Finland Birth Cohort 1986 ($n = 1,773$). The outcome measures were 6-month period prevalences of NP, SP and LBP. The quantity and quality of sleep were categorized into sufficient, intermediate or insufficient, based on average hours spent sleeping, and whether or not the subject suffered from nightmares, tiredness and sleeping problems. The odds ratios (OR) and 95% confidence intervals (CI) for having musculoskeletal pain were obtained through logistic

regression analysis, adjusted for previously suggested risk factors and finally adjusted for specific pain status at 16 years. The 6-month period prevalences of neck, shoulder and low back pain were higher at the age of 18 than at 16 years. Insufficient quantity or quality of sleep at 16 years predicted NP in both girls (OR 4.4; CI 2.2–9.0) and boys (2.2; 1.2–4.1). Similarly, insufficient sleep at 16 years predicted LBP in both girls (2.9; 1.7–5.2) and boys (2.4; 1.3–4.5), but SP only in girls (2.3; 1.2–4.4). After adjustment for pain status, insufficient sleep at 16 years predicted significantly only NP (3.2; 1.5–6.7) and LBP (2.4; 1.3–4.3) in girls. Insufficient sleep quantity or quality was an independent risk factor for NP and LBP among girls. Future studies should test whether interventions aimed at improving sleep characteristics are effective in the prevention and treatment of musculoskeletal pain.

Keywords Musculoskeletal pain · Adolescent · Sleep · Risk factors · Prospective study

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Introduction

The prevalence of neck pain (NP), shoulder pain (SP) and low back pain (LBP) among Finnish adolescents has increased over the recent decades [12]. Adolescence is defined as the 10-year life period between 10 and 19 years [50]. The 6-month prevalence of NP/SP was 38% at 16 years and 45% at 18 years in girls, and 16 and 19%, respectively, in boys in a large Finnish study of 62,677 adolescents [12]. In the same study, the 6-month prevalence of LBP was 14% in girls and 11% in boys at 16 years, and 17% in girls and 13% in boys at 18 years. The 1-year prevalence of NP/SP varied between 19 and 78% in girls and 10 and 63% in boys aged 14–18 years [34,

41], while the 1-year prevalence of LBP varied between 20 and 52% in girls and 15 and 49% in boys aged 13–16 years [13, 41, 48].

The prevalence of pain at these locations increases with age [12, 19, 32, 42, 44, 55]. The etiology of adolescent NP, SP and LBP still remains largely unclear. Some lifestyle factors may associate with these pains, such as smoking [29, 31, 38], high level of physical activity [2, 3, 19, 25, 33, 42] and a great deal of sitting [2, 3, 11, 42]. In addition, psychosocial symptoms [9, 11, 18, 23] and obesity [5, 32] have also been suggested to increase the risk of LBP in adolescence.

Technology and the media, e.g., television, computers and the Internet have restructured the daily routines of many adolescents, resulting in poorer sleep quality on average [24]. Insufficient quantity and quality of sleep could well be related to the increased prevalence of musculoskeletal pains. Some early studies suggest that tiredness, difficulties in falling asleep, waking up at night and other sleep problems are risk factors for musculoskeletal pains [10, 42, 47, 52]. A cohort-based, long-term follow-up study among adults showing that sleep disturbances predict hospitalizations for back disorders [21] confirmed earlier observations, although the results may have been confounded by occupational factors. The quantity and quality of sleep could be a potentially modifiable risk factor for musculoskeletal pains.

We investigated whether insufficient quality and quantity of sleep are risk factors for neck, shoulder and low back pain in a large general population of adolescents. The hypothesis was that both insufficient quantity and quality of sleep at 16 years of age predict NP, SP and LBP at the age of 18 years. The mechanisms that could potentially explain our hypothesis are: (1) changes in pathophysiological pathways (inflammation); (2) increased distress and strain and thereby increased muscle tone and prevalence of minor injuries; or (3) a simply lower pain threshold among insomniac adolescents.

Materials and methods

Study population

The study population belonged to the 1986 Northern Finland Birth Cohort (NFBC 1986), consisting of children with an expected date of birth between 1 July 1985 and 30 June 1986 ($n = 9,479$) in the two northernmost provinces of Finland, Oulu and Lapland [20]. The 15–16-year follow-up conducted in 2001–2002 included a postal questionnaire, which was sent to the members of the cohort who were alive and whose addresses were known ($n = 9,215$). The response rate was 75%. The questionnaire included

items regarding their health, including musculoskeletal pain and health habits, such as physical activity, sedentary behavior, quality and quantity of sleep, smoking, weight and height. In 2003–2004, a second postal questionnaire, which included items, i.e., musculoskeletal health, was sent to a subgroup of this birth cohort living within 100 km of the city of Oulu ($n = 2,969$, not randomized). Altogether, 2,012 members responded to this survey (response rate, 68%). The present analyses included the 1,773 adolescents who responded to both questionnaires. The study conformed to the principles of the Declaration of Helsinki. The participants took part on a voluntary basis and signed their informed consent. The data were handled on a group level only and personal information was replaced by ID codes. The research protocol was approved by the Ethics Committee of the University Hospital of Oulu.

Musculoskeletal pains

Self-reported 6-month period prevalences of neck–occipital, shoulder, and low back pains at the age of 16 and 18 years were evaluated by a postal inquiry consisting of the following questions: “Have you had any aches or pains during the last 6 months in the following areas of your body?” (1) Neck or occipital area, (2) shoulders and (3) low back. These anatomical areas were also indicated with a drawing. The response alternatives were: (a) no, (b) yes, but I have not consulted a physician, physiotherapist, nurse or other health professional about these pains (defined as reporting pain), and (c) yes, and I have consulted a physician, physiotherapist, nurse or other health professional about these pains (defined as consultation for pain). The pain variable was dichotomized as (a) no pain and (b) pain (with or without consultation).

Quantity and quality of sleep

The quantity and quality of sleep were evaluated in the postal questionnaire at 16 years by asking the average hours spent sleeping and “How well does each statement apply at present, or over the past 6 months?” (1) “I have nightmares”, (2) “I am too tired” and (3) “I have sleep problems”. The response alternatives were: (a) never, (b) to some extent or sometimes and (c) very well or often. These three statements were derived from the Youth Self-Report (YSR), which has been designed to assess adolescents’ emotional and behavioral problems [1]. Based on both sleep quantity and quality, a three-category composite variable was formed a priori and labeled as sleep quantity and quality variable: (1) *insufficient sleep quality or quantity* was defined as sleeping 6 h or less per day, or often having nightmares, tiredness or general sleep problems; (2) *intermediate sleep quantity and quality* was

defined as sleeping 7 or 10 h or more per day, or having nightmares, tiredness or general sleep problems to some extent or sometimes; and (3) *sufficient quality and quantity of sleep* was defined as sleeping the recommended 8–9 h per day [7, 8] and having no nightmares, tiredness or general sleep problems. All subjects fall in one of the three classes.

Confounding factors

Previously suggested risk factors for NP, SP and LBP were considered as potentially confounding factors in the analyses. These included the level of physical activity [2, 5, 25, 26, 42], time spent in different sedentary activities [2, 3, 25, 42], smoking [5, 31, 32] and the level of obesity [5, 32]. Additionally, the adolescents' moods of unhappiness, sadness and depression [9, 18], and their parents' self-reported socioeconomic status [31] were included as confounders.

Concerning the level of physical activity, the adolescents were classified into five groups according to their participation in moderate-to-vigorous and light physical activity outside school hours and a physically active journey to school: (1) very active, (2) active, (3) moderately active, (4) somewhat active and (5) inactive [49]. Subjects also reported how many hours a day on average they spent in the following sedentary activities outside school hours: watching television, reading books or magazines, playing or working on a computer and other sitting activities [49]. The total time spent on all of these sedentary activities was also calculated and categorized as: (1) 4 h a day or less, (2) 4.1–7.9 h per day and (3) 8 h or more per day. Body weight and height were both self-reported in the postal inquiry and measured in the physical examination at the age of 15–16 years with an accuracy of 0.1 kg and 1 cm, respectively. The elicited body weight and height were used for those who did not participate in the physical examination. Body mass index (BMI) was calculated as weight/height^2 (kg/m^2). Overweight was defined as BMI between the 85th and 95th percentiles (24.10–27.88 kg/m^2 among boys and 23.95–27.30 kg/m^2 among girls), and obesity as BMI above the 95th percentile (≥ 27.89 kg/m^2 in boys and ≥ 27.31 kg/m^2 in girls) [54]. Smoking status at 16 years was elicited by the questions: “Have you ever smoked in your life?”, “Do you currently smoke?”, and question on the frequency of smoking. Smoking status was categorized as: no smoking at all, smoking 4 days per week or less often, and smoking 5–7 days per week. Parents' socioeconomic status (father's status; if not known, mother's status) was elicited and categorized into five groups: (1) superior clerical employees, (2) self-employed persons, (3) lower clerical employees, (4) employees, and (5) students, senior citizens, unemployed and unknowns. Adolescents

also answered how well the following statement applied at present or over the past 6 months “I feel unhappy, sad or depressed” [1]. The response alternatives were: (a) never, (b) to some extent or sometimes, and (c) very much or often.

Statistical analysis

Logistic regression analyses were used to evaluate whether the a priori formed sleep quantity and quality variable at the age of 16 years predicted NP, SP and LBP at the age of 18 years [40]. In addition, associations between independent measures of sleep quantity (average hours spent sleeping) and quality (having nightmares, tiredness and general sleep problems) at 16 years, and NP, SP and LBP at the age of 18 years were analyzed. Firstly, adjustments were made for sedentary activities, level of physical activity, smoking, body mass index, parents' socioeconomic status and depressive mood at the age of 16 years. Finally, odds ratios were also adjusted for specific pain status at 16 years. Both of those odds ratios (OR) and their 95% confidence intervals (CI) are shown in Tables 3 and 4.

Results

Among both genders, the 6-month period prevalences of all assessed musculoskeletal pains were higher at the age of 18 than at 16 years ($P < 0.001$, Table 1). Girls reported more NP, SP and LBP than boys at both time points ($P < 0.001$). Insufficient quantity and quality of sleep at the age of 16 years was also more common among girls than in boys ($P < 0.001$, Table 2). On average, boys slept more than girls ($P < 0.001$), whereas girls reported having more nightmares, being more tired and having more general sleep problems than boys ($P < 0.001$).

Among girls, sleeping 7 h or less at 16 years was associated with the highest prevalence of NP, SP and LBP at 18 years; but after adjusting for pain status at 16 years, statistically significant associations disappeared (Table 3). Among girls, being often too tired at 16 years was associated with the highest prevalence of NP and LBP at 18 years, and associations remained statistically significant after adjusting for baseline pain status. Having general sleep problems at 16 years was associated with the highest prevalence of NP, SP and LBP at 18 years; but after adjusting for baseline pain status, statistically significant associations only remained for NP (Table 3).

Among boys, sleeping 9 h per day at 16 years of age was associated with the highest prevalence of LBP at 18 years (Table 3). In addition, being often too tired at 16 years was associated with the highest prevalence of NP, SP and LBP at 18 years; but after adjusting for baseline

Table 1 Prevalence of musculoskeletal pain at the age of 16 and 18 years

	Girls % (<i>N</i> = 981)		Boys % (<i>N</i> = 792)	
	At 16 years	At 18 years	At 16 years	At 18 years
Prevalence of neck or occipital pain				
No pain	50.2 (488)	26.1 (254)	65.2 (508)	50.6 (390)
Reporting pain ^a	45.6 (444)	65.5 (637)	33.1 (258)	47.3 (364)
Consultation for pain ^b	4.2 (41)	8.3 (81)	1.7 (13)	2.1 (16)
Prevalence of shoulder pain				
No pain	42.1 (410)	27.3 (265)	65.5 (508)	56.9 (436)
Reporting pain ^a	52.0 (506)	63.4 (616)	32.6 (253)	40.1 (307)
Consultation for pain ^b	6.0 (58)	9.3 (90)	1.9 (15)	3.0 (23)
Prevalence of low back pain				
No pain	52.4 (510)	37.5 (362)	64.3 (500)	53.2 (411)
Reporting pain ^a	42.8 (416)	56.4 (544)	31.4 (244)	41.3 (319)
Consultation for pain ^b	4.8 (47)	6.1 (59)	4.4 (34)	5.4 (42)
The level of physical activity				
Very active	11.1 (107)		24.6 (191)	
Active	19.7 (190)		22.3 (173)	
Moderately active	31.3 (302)		22.0 (171)	
Somewhat active	30.6 (296)		21.5 (167)	
Inactive	7.3 (71)		9.5 (74)	
Sitting time per day				
≥8 h	25.5 (238)		32.7 (243)	
4.1–7.9 h	41.6 (389)		44.3 (329)	
≤4 h	32.9 (307)		22.9 (170)	
Mood of unhappiness and depression				
Not at all	53.4 (520)		80.1 (618)	
Sometimes or often	46.6 (453)		19.9 (154)	
Parent's socioeconomic status				
Superior clerical employees	29.2 (257)		31.9 (233)	
Self-employed persons	10.4 (91)		9.6 (70)	
Lower clerical employees	20.5 (180)		21.5 (157)	
Employees	35.8 (315)		33.8 (247)	
Students, senior citizens, unemployed, unknowns	4.1 (36)		3.2 (23)	
Smoking				
Not at all	63.5 (615)		70.7 (545)	
Four days per week or less often	21.1 (204)		16.2 (125)	
Five to seven days per week	15.4 (149)		13.1 (101)	

^a Individuals had not consulted a physician, physiotherapist, nurse or a health professional because of pain

^b Individuals had consulted a physician, physiotherapist, nurse or a health professional because of pain

pain status, statistically significant associations only remained for SP (Table 3).

Among girls, insufficient quantity or quality of sleep at 16 years predicted increased prevalence of NP, SP and LBP at 18 years. After adjusting for baseline pain status, these associations remained statistically significant for NP and LBP (Table 4). Having intermediate quantity and quality of sleep at 16 years predicted an increased

prevalence of NP and LBP at 18 years; but after adjusting for baseline pain status, significant associations only remained for LBP (Table 4). For boys, having insufficient quantity or quality of sleep at 16 years predicted increased prevalence of NP and LBP; but after adjusting for baseline pain status, statistically significant associations expired (Table 4). Having intermediate quantity and quality of sleep at 16 years of age predicted increased prevalence of

Table 2 Sleep quantity and quality at the age of 16 years

	Girls % (N)	Boys % (N)
Average hours spent sleeping		
6 h or less	5.5 (54)	3.4 (26)
7 h	17.9 (175)	13.8 (107)
8 h	44.7 (437)	43.5 (337)
9 h	21.3 (208)	23.7 (184)
10 h or more	10.5 (103)	15.6 (121)
I have nightmares		
Often	1.4 (14)	0.5 (4)
Sometimes	45.8 (443)	18.8 (145)
Not at all	52.8 (511)	80.7 (624)
I am too tired		
Often	9.3 (90)	4.8 (37)
Sometimes	53.2 (515)	36.0 (278)
Not at all	37.5 (363)	59.2 (457)
I have sleeping problems		
Often	3.2 (31)	3.2 (25)
Sometimes	16.2 (156)	7.4 (57)
Not at all	80.6 (777)	89.4 (690)
Quality and quantity of sleep ^a		
Sufficient quality and quantity of sleep	17.1 (164)	33.2 (249)
Intermediate quality and quantity of sleep	66.5 (638)	57.1 (428)
Insufficient quality or quantity of sleep	16.4 (157)	9.6 (72)

^a Composite variable formed based on quantity and quality of sleep

NP and SP at 18 years, even after adjusting for baseline pain status (Table 4).

Discussion

The results of this prospective study showed that insufficient quantity or quality of sleep at the age of 15–16 years predicted NP and LBP in girls aged 18–19 years, even after adjustments for the previously suggested determinants and risk factors for these pains, and baseline pain status. The results of the logistic regression analyses changed after adjusting for baseline pain status.

The large representative adolescent population and high response rate, which is common in Finland, are the main strengths of this study. In addition, it was possible in the analyses to take into account and adjust for several other risk factors. Objective laboratory measurements, such as electroencephalography (EEG) during sleep, would be the most valid way to measure quality and quantity of sleep, but such measurements are not feasible in large population-based cohorts such as NFBC 1986. Our study, as in other similar epidemiological studies, relied on self-reporting for lack of more objective methods to measure pain. The

clinical relevance of the pains may be questioned, since the prevalence was so high. Obviously, reporting these pains does not necessarily mean any limitation in daily activities or quality of life. However, the validity of the pain questionnaire has been previously concluded as being comparable to an interview [45]. Furthermore, the questionnaire did not specifically differentiate menstruation pain from other types of LBP among girls, which may partly explain the higher prevalence of “reporting LBP” among girls. The selection bias of this subpopulation has previously been analyzed by Mikkonen et al. [29]. Those who responded at 18 years had somewhat healthier lifestyles, were more likely to live in two-parent families and girls were more likely to be slimmer and non-smokers at 16 years compared to those who did not participate in the follow-up study at 18 years [29].

Such studies have been conducted previously on relatively small populations or using cross-sectional or case-control designs, which limit the credibility of their findings on the potential role of sleep problems on musculoskeletal pains in adolescent populations. The majority of previous findings are, nevertheless, consistent with our results. Among longitudinal studies, daytime tiredness predicted musculoskeletal pains in a 1-year follow-up of 363 children [28], and waking up at night predicted musculoskeletal pains among girls in a 4-year follow-up of the same population [10]. Difficulty in falling asleep increased the risk of low back pain in a 2-year follow-up of 287 children aged 9–12 years [47]. Sleeping difficulties and symptoms of fatigue in adolescence were significantly associated with a higher prevalence of neck-shoulder pain in adulthood in a follow-up of 394 individuals [42].

Total sleeping time has not previously been included as part of the evaluation of poor sleep in studies of pain epidemiology, although decreased total sleeping time has been suggested to be a component of chronic insomnia. Carskadon et al. [7, 8] have shown in two studies that adolescents require 8.5–9.2 h of sleep per night. In a study by Oginska and Pokorski, self-reported need for sleep per day was 9 h 23 min among schoolchildren and 8 h 22 min among university students [36]. Subsequently, those sleeping 8–9 h per day were used as a reference group in the present study.

The results of the present study fulfill almost all of Hill’s classic criteria of causality [15]. A dose-response relationship appeared between the level of insufficient sleep and musculoskeletal pain; with regard to temporality, pains occurred after insufficient sleep. The odds ratios describing the relationships between insufficient sleep and musculoskeletal pain in the evaluated anatomical areas were relatively high, which also strengthens the possibility of causality between these variables. There are several plausible mechanisms to explain an association between

Table 3 Logistic regression of quality and quantity of sleep at 16 years on musculoskeletal pains at the age of 18 years

	Neck or occipital pain			Shoulder pain			Low back pain		
	% (N)	OR (CI)	Adjusted for pain at 16 years, OR (CI)	% (N)	OR (CI)	Adjusted for pain at 16 years, OR (CI)	% (N)	OR (CI)	Adjusted for pain at 16 years, OR (CI)
Girls									
Average hours spent sleeping									
7 h or less	79.3 (180)	1.58 (1.00–2.48)	1.44 (0.90–2.32)	78.8 (178)	1.55 (0.99–2.44)	1.36 (0.85–2.17)	69.9 (158)	1.55 (1.04–2.31)	1.45 (0.96–2.19)
8 h	70.2 (304)	1.00	1.00	69.9 (302)	1.00	1.00	61.1 (261)	1.00	1.00
9 h	72.2 (148)	0.99 (0.65–1.49)	1.02 (0.66–1.57)	70.9 (146)	1.08 (0.71–1.63)	1.17 (0.76–1.81)	56.7 (118)	0.84 (0.57–1.22)	0.86 (0.58–1.27)
10 h or more	80.6 (83)	1.67 (0.92–3.03)	1.55 (0.84–2.87)	74.8 (77)	1.14 (0.65–1.99)	1.08 (0.61–1.93)	64.0 (64)	0.92 (0.56–1.52)	0.87 (0.52–1.47)
I have nightmares									
Sometimes or often	76.2 (345)	1.14 (0.81–1.58)	1.03 (0.72–1.46)	75.3 (339)	1.22 (0.88–1.70)	1.09 (0.77–1.54)	67.3 (302)	1.24 (0.92–1.67)	1.13 (0.83–1.54)
Not at all	71.9 (364)	1.00	1.00	70.5 (358)	1.00	1.00	58.7 (296)	1.00	1.00
I am too tired									
Often	91.1 (82)	4.78 (1.94–11.85)	3.92 (1.55–9.90)	81.8 (72)	2.01 (0.96–4.22)	1.78 (0.83–3.83)	76.1 (67)	2.61 (1.37–4.99)	2.42 (1.24–4.71)
Sometimes	77.9 (398)	1.80 (1.26–2.58)	1.46 (1.00–2.13)	76.1 (388)	1.41 (0.99–2.02)	1.21 (0.83–1.76)	65.0 (331)	1.48 (1.07–2.06)	1.32 (0.93–1.85)
Never	63.4 (227)	1.00	1.00	65.3 (235)	1.00	1.00	55.9 (199)	1.00	1.00
I have sleeping problems									
Sometimes or often	84.4 (157)	1.83 (1.13–2.98)	1.67 (1.00–2.78)	82.5 (151)	1.63 (1.02–2.60)	1.47 (0.91–2.39)	72.8 (134)	1.63 (1.09–2.44)	1.48 (0.97–2.24)
Never	71.4 (549)	1.00	1.00	70.2 (541)	1.00	1.00	60.4 (463)	1.00	1.00
Boys									
Average hours spent sleeping									
7 h or less	59.7 (77)	1.46 (0.91–2.34)	1.40 (0.86–2.30)	48.4 (62)	1.10 (0.69–1.76)	1.05 (0.66–1.69)	54.2 (71)	1.53 (0.96–2.44)	1.42 (0.86–2.33)
8 h	48.2 (159)	1.00	1.00	44.1 (145)	1.00	1.00	44.5 (147)	1.00	1.00
9 h	47.8 (85)	1.04 (0.69–1.57)	0.98 (0.64–1.50)	39.7 (69)	0.87 (0.57–1.32)	0.84 (0.55–1.29)	50.0 (88)	1.51 (1.00–2.27)	1.59 (1.03–2.44)
10 h or more	44.0 (51)	0.75 (0.46–1.23)	0.86 (0.52–1.44)	39.0 (46)	0.75 (0.46–1.22)	0.85 (0.51–1.39)	42.4 (50)	0.85 (0.53–1.38)	0.93 (0.56–1.54)
I have nightmares									
Sometimes or often	56.0 (79)	1.40 (0.92–2.13)	1.35 (0.87–2.11)	50.7 (72)	1.41 (0.93–2.14)	1.28 (0.84–1.96)	46.9 (67)	0.97 (0.64–1.47)	0.89 (0.58–1.39)
Never	48.5 (296)	1.00	1.00	41.5 (251)	1.00	1.00	47.4 (289)	1.00	1.00
I am too tired									
Often	60.0 (21)	1.74 (0.76–3.96)	1.15 (0.48–2.74)	52.9 (18)	1.71 (0.76–3.85)	1.36 (0.60–3.13)	63.9 (23)	2.36 (1.04–5.39)	1.46 (0.61–3.45)
Sometimes	58.4 (160)	1.67 (1.18–2.37)	1.28 (0.88–1.85)	51.8 (141)	1.77 (1.25–2.51)	1.57 (1.10–2.25)	51.5 (140)	1.39 (0.98–1.96)	1.16 (0.80–1.68)
Never	44.2 (195)	1.00	1.00	37.3 (164)	1.00	1.00	43.2 (192)	1.00	1.00
I have sleeping problems									
Sometimes or often	54.4 (43)	1.09 (0.64–1.84)	0.83 (0.48–1.44)	51.3 (40)	1.37 (0.81–2.31)	1.32 (0.77–2.25)	56.8 (46)	1.39 (0.83–2.34)	1.14 (0.66–2.00)
Not at all	49.0 (329)	1.00	1.00	42.1 (281)	1.00	1.00	45.9 (308)	1.00	1.00

Odds ratios (OR) and their 95% confidence intervals (CI) are adjusted for sedentary activities, level of physical activity, smoking, body mass index, parents' socioeconomic status, moods of depression and pain at age 16 years

Table 4 Logistic regression of quality and quantity of sleep (composite variable) at 16 years on musculoskeletal pains at the age of 18 years

	Neck or occipital pain			Shoulder pain			Low back pain		
	% (N)	OR (CI)	Adjusted for pain at 16 years, OR (CI)	% (N)	OR (CI)	Adjusted for pain at 16 years, OR (CI)	% (N)	OR (CI)	Adjusted for pain at 16 years, OR (CI)
Girls									
Quality and quantity of sleep									
Insufficient	87.3 (137)	4.39 (2.15–8.96)	3.20 (1.54–6.68)	81.9 (127)	2.26 (1.17–4.36)	1.63 (0.82–3.24)	70.3 (109)	2.94 (1.66–5.21)	2.41 (1.34–4.34)
Intermediate	73.9 (466)	1.69 (1.11–2.56)	1.36 (0.88–2.11)	72.4 (457)	1.27 (0.83–1.94)	0.94 (0.60–1.47)	64.9 (408)	2.00 (1.33–3.00)	1.66 (1.09–2.53)
Sufficient	60.5 (98)	1.00	1.00	63.2 (103)	1.00	1.00	45.3 (73)	1.00	1.00
Boys									
Quality and quantity of sleep									
Insufficient	60.3 (41)	2.17 (1.15–4.09)	1.60 (0.82–3.12)	47.1 (32)	1.38 (0.74–2.59)	1.18 (0.62–2.24)	62.0 (44)	2.38 (1.26–4.49)	1.64 (0.83–3.21)
Intermediate	54.1 (224)	1.58 (1.10–2.28)	1.47 (1.00–2.14)	46.7 (193)	1.48 (1.02–2.15)	1.47 (1.01–2.16)	47.2 (196)	1.12 (0.78–1.62)	1.02 (0.70–1.50)
Sufficient	40.0 (98)	1.00	1.00	35.1 (85)	1.00	1.00	42.8 (104)	1.00	1.00

Odds ratios (OR) and their 95% confidence intervals (CI) are adjusted for sedentary activities, level of physical activity, smoking, body mass index, parents' socioeconomic status, moods of depression and pain at age of 16 years

insufficient sleep and pain in the neck, shoulder and low back area. Most known risk factors for musculoskeletal pain were included in the analyses, and the association still remained after adjustments. Moreover, the results are in line with previous studies. However, there are also other possible causal mechanisms, e.g., distress and anxiety are the causal factors and insufficient sleep has a mediating effect, being merely a risk indicator. Insufficient sleep is also known to cause multiple other effects besides musculoskeletal pains. In all, a randomized controlled intervention study would optimally be needed to confirm the causality between insufficient sleep and musculoskeletal pains.

The etiology of insufficient quantity and quality of sleep in adulthood is different from that in adolescence and childhood. Adolescents' social pressures and activities, such as after-school sports, evening jobs, use of the Internet and mobile phones, watching television and doing homework at night, consumption of caffeine, nicotine and illicit drugs, combined with getting up early for school, often result in insufficient sleep duration, daytime sleepiness and inadequate sleep hygiene [42].

The relations among psychological symptoms, quantity and quality of sleep, and musculoskeletal pains are complex. Reciprocal relations among anxiety, distress, strain, depression and sleep disturbances have been suggested earlier [4, 6, 30, 56]. These psychological symptoms are closely linked to obesity, smoking and physical inactivity [14, 17, 22, 35, 43, 51, 53], which have been suggested as risk factors for neck, shoulder and low back pains in adolescence [5, 25, 31, 32, 42]. Our findings that insufficient quantity or quality of sleep increases the risk of neck and low back pains independently of depressive mood, physical activity, sedentary behavior, smoking, BMI and parents' socioeconomic status may indicate that it has a mediating effect, explaining the relationship between social pressures, psychological symptoms and musculoskeletal pains. Of note is that depressive mood, which was used as a confounder in the present study, is not equal to clinical depression. The results might be partly explained by a lower pain threshold among anxious, distressed and insomniac adolescents.

Another hypothesis is that insufficient quantity and quality of sleep causes musculoskeletal disorders by a (patho) physiological pathway. Subsequent activation of inflammatory mediators via cortisol and cytokine networks has been suggested as one of the possible mechanisms in a prospective study where sleep disturbances predicted hospitalization due to back disorders [21]. Insufficient sleep is concluded to increase the concentration of cytokines and inflammatory mediators [16, 27]. Findings that chronic stress, obesity and smoking also increase the concentration of inflammatory factors [39]

are in line with the hypothesis that inflammation may mediate the relation among insufficient quality and quantity of sleep, other psychological risk factors, and neck, shoulder and low back disorders.

Other mechanisms by which insufficient quantity and quality of sleep may increase the likelihood of musculoskeletal pains are the inhibition of muscle relaxation and activation of the sympathetic nervous system via distress and strain, thereby increasing muscle tone and increasing the risk for pain and injuries of muscular origin. It has been suggested that sleep disturbances increase the risk of injuries by lowering cognitive function [46]. Sleep–wake patterns are also related to risk-taking behavior in adolescence [37].

Conclusions

The present findings suggest that insufficient quantity or quality of sleep is an independent risk factor or at least concomitant with neck and low back pain. The potential mechanisms behind the effect of insufficient quantity and quality of sleep on neck and low back pains are highly speculative and require further research. In addition, intervention studies should be carried out to test whether interventions aimed at improving quality and/or increasing quantity of sleep are effective in the prevention and treatment of musculoskeletal pains.

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